Fractures requiring inpatient care

– incidence and post-fracture mortality

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Academic Dissertation

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Abstract

Hip fractures have been extensively studied with regard to both incidence and post-fracture mortality. However, limited data exist on the incidence of fractures – other than hip fractures – requiring inpatient care, even though they account for considerable morbidity and healthcare costs. Moreover, previous research on post-fracture mortality has focused on older age groups, although the highest number of potential years of life is lost when a young person dies.

This thesis is based on register data of nearly 6000 patients older than 15 years who were treated on the trauma ward of Central Finland Hospital (CFH) between 2002 and 2008. The purpose was to investigate the incidence of all fractures requiring inpatient care. In addition, the post-fracture mortality and causes of death were determined for all patients hospitalized for extremity fracture treatment. We also investigated the post-fracture mortality and causes of death of the youngest age group (16-30 years) separately to determine whether mortality in this group differs from the expected mortality.

During the study period 3277 women and 2708 men sustained 3750 and 3030 fractures, respectively. The incidence of all fractures was 4.9 per person-year (95% CI: 4.8 to 5.0). Fractures of the hip, ankle, wrist, spine, and proximal humerus comprised two-thirds of all fractures requiring hospitalization.

A total of 929 women and 753 men sustained at least one upper extremity fracture, and 2081 women and 1486 men at least one lower extremity fracture. The standardized mortality ratio (SMR) of all fracture patients was 1.83 (95% CI: 1.75 to 1.91); 1.65 (95% CI: 1.56 to 1.75) for women and 2.56 (95% CI: 2.09 to 2.43) for men. We found that the combined proportion of ankle (17%) and wrist (9%) fractures was equal to that of hip fractures (27%). Although the mortality after lower extremity fractures generally was higher than after upper extremity fractures, in men the 4.50 (95% CI: 3.31 to 6.11) SMR after proximal humerus fractures was even higher than the 3.0 (95% CI: 2.7 to 3.3) SMR after hip fractures.

Altogether 724 patients (72.5% men), aged 16 to 30 years, were hospitalized for treatment of a fracture in CFH between 2002 and 2008. Ankle, tibia, spine, forearm, and wrist constituted the five most common fracture sites. The SMR of all patients, aged 16 to 30 years, was 6.17 (95% CI: 4.29 to 8.88). In this age group, there were no deaths during the treatment period that were associated with the index fracture. Suicide (28%) and intoxication (24%) were the leading primary causes of death. Our results

suggest that in some young adults who had received in-patient fracture care, an underlying, undiagnosed, serious mental illness may have been present, potentially explaining the high SMR. Health professionals should consider the possibility of a severe, undiagnosed mental illness when treating young adults hospitalized for a fracture.

Yhteenveto

Lonkkamurtumien ilmaantuvuutta ja niihin liittyvää kuolleisuutta on tutkittu laajasti. Vaikka muihin sairaalahoitoa vaativiin murtumiin liittyy huomattavaa sairastavuutta ja terveydenhuollon kustannuksia, näitä murtumia on tutkittu puutteellisesti. Perinteisesti murtumatutkimus on keskittynyt iäkkäämpiin potilaisiin, siitä huolimatta, että nuoren henkilön menehtyessä menetetään suurempi määrä potentiaalisia elinvuosia.

Tämä väitöskirja perustuu Keski-Suomen keskussairaalassa (KSKS) tapaturmaosastolla vuosina 2002-2008 kerättyyn aineistoon osastohoitoa vaatineista murtumista. Aineisto käsitti yli kuuden tuhannen 16 vuotta täyttäneen potilaan tiedot. Tutkimuksessa selvitettiin kaikkien sairaalahoitoa vaatineiden murtumien ilmaantuvuus sekä raajamurtumiin liittyvä kuolleisuus. Erityisesti tutkimuksessa keskityttiin 16-30-vuotiaiden murtumapotilaiden kuolleisuuteen. Vertailukohtana oli muun saman ikäisen väestön kuolleisuus.

Tutkimuksen aikana 3277 naista sai 3750 murtumaa ja 2708 miestä 3030 murtumaa. Kaikkien murtumien ilmaantuvuus oli yhteensä 4,9 murtumaa henkilövuotta kohti (95% CI: 4,8 – 5,0). Lonkka-, nilkka-, ranne-, ranka- ja olkaluun yläosan murtumat käsittivät kaksi kolmasosaa kaikista sairaalahoitoa vaatineista murtumista.

929 naista ja 753 miestä sai vähintään yhden yläraajan murtuman ja 2081 naista ja 1486 miestä vähintään yhden alaraajan murtuman. Kaikkien edellä mainittujen potilaiden vakioitu kuolleisuussuhde (SMR, standardized mortality ratio) oli 1,83 (95% CI: 1,75 – 1,91); naisilla 1,65 (95% CI: 1,56 – 1,75) ja miehillä 2,56 (95% CI: 2,09 to 2,43). Totesimme, että nilkka- (17%) ja rannemurtumien (9%) yhdistetty ilmaantuvuus oli samanlainen kuin lonkkamurtumien ilmaantuvuus (27%). Yleisesti yläraajamurtumien jälkeinen kuolleisuus oli pienempää kuin alaraajamurtumien jälkeinen kuolleisuus. Poikkeuksen muodostivat miesten olkaluun yläosan murtumat. Kuolleisuus näillä potilailla (SMR 4,50 (95% CI: 3,31 – 6,11)) oli jopa suurempaa, kuin lonkkamurtumien jälkeen todettu kuolleisuus (SMR 3,0 (95% CI: 2,7 to 3,3)).

724 16-30 vuoden ikäistä (72,5% miehiä) potilasta hoidettiin KSKS:n tapaturmaosastolla vuosina 2002-2008. Nilkan, sääriluun, rangan, käsivarren ja ranteen murtumia todettiin eniten. Kaikkien 16-30 vuotiaiden potilaiden SMR oli 6,17 (95% CI: 4,29 to 8,88). Kukaan potilaista ei kuollut

indeksimurtumaan liittyvällä hoitojaksolla. Yleisimmät kuolinsyyt olivat itsemurha (28%) ja myrkytys (24%). Toteamamme huomattava kuolleisuus saattaa osaltaan johtua nuorten murtumapotilaiden mahdollisesta toteamattomasta vakavasta mielenterveyden häiriöstä. Terveydenhuollon ammattilaisten tulisi pitää mielessä, että osa nuorista sairaalassa hoidettavista murtumapotilaista saattaa sairastaa toteamatonta vakavaa psykiatrista sairautta.

Table of Contents

1. List of original publications

This thesis is based on the following original publications referred to in the text by their Roman numerals:

I. Somersalo A, Paloneva J, Kautiainen H, Lönnroos E, Heinänen M, Kiviranta I. Incidence of fractures requiring inpatient care. Acta Orthop 2014; 85 (5): 525-530.

II. Somersalo A, Paloneva J, Kautiainen H, Lönnroos E, Heinänen M, Kiviranta I. Increased mortality after upper extremity fracture requiring inpatient care. Acta Orthop 2015; 86 (5): 533-557.

III. Somersalo A, Paloneva J, Kautiainen H, Lönnroos E, Heinänen M, Kiviranta I. Increased mortality after lower extremity fractures in patients < 65 years of age. Acta Orthop. 2016 ;87(6):622-625.

IV. Somersalo A, Paloneva J, Lonnroos E, Heinanen M, Koponen H, Kiviranta I. Six-fold post-fracture mortality in 16- to 30-year-old patients – suicides, homicides and intoxications among leading causes of death. Scand J Surg 2018 May 01;1457496918772371

2. List of abbreviations

AO/OTA	Association for the Study of Internal Fixation/American Orthopaedic Trauma Association
BMD	Bone Mineral Density
BMU	Basic Multicellular Unit
CFH	Central Finland Hospital
CFHD	Central Finland Health Care District
CI	Confidence Interval
DXA	Dual Energy X-ray Absorptiometry
HR	Hazard ratio
ICD-10	International Classification of Diseases, 10th revision
IRR	Incidence rate ratio
MVA	Motor vehicle accident
NOMESCO	Nordic Medico-Statistical Committee
ORIF	Open reduction internal fixation
SD	Standard deviation
SMR	Standardized Mortality Ratio

3. Introduction

Bone fractures are common with an incidence of 100-130/10 000 person-years (1-3). Altogether 44% and 25% of women and men, respectively, over 60 years of age will sustain a fracture due to a low-energy trauma during their remaining lifetime (4). Many fractures can be treated in an outpatient setting (5). However, surgery may be recommended if the fracture is severely dislocated, closed reduction is impossible, or sufficient stability is unachievable by immobilization (6-8). Direct costs are significantly increased if surgery is needed (9). Due to the long healing time of fractures, patients frequently return late to work. This further increases costs. By contrast, after hip fractures the long-term costs of fracture treatment are lower after operative fracture treatment due to functional limitations in patients treated non-operatively (10). Patients with fracture of the tibial shaft achieve better and earlier functional results if treated with surgery (11). Except for hip fractures, there has been little research on the incidence of fractures requiring inpatient care, and the current profile of fractures sustained by adults admitted to trauma units is unknown. This profile is likely to differ from the overall fracture profile in a population.

Similarly, post-fracture mortality research has traditionally focused on post-hip-fracture mortality. In fact, an increased mortality after hip fractures of the magnitude of 2-3 times that of the general population is well documented (12,13). In addition, osteoporotic vertebral fractures are associated with increased mortality (1,14,15). However, studies on non-hip non-vertebral fractures are limited and inconclusive (16-20).

The highest number of potential years of life is lost when a young individual dies. Some studies have indicated that the relative mortality is increased in younger age groups (16,21). However, this phenomenon has not previously been investigated in adults younger than 30 years.

Based on a register including nearly 7000 treatment periods, this doctoral thesis aimed to investigate the incidence of fractures requiring inpatient care in adults of all ages. In addition, post-fracture mortality was assessed for all hospitalized extremity fractures. Post-fracture mortality and causes of death of patients aged 16-30 years were investigated separately.

4. Review of the literature

4.1 Function of the skeleton

The human skeleton, formed by numerous bones, provides structural rigidity to the body, enables movement, and protects the inner organs (22). In addition to this mechanical function, bones participate in the maintenance of calcium and phosphorus homeostasis. Recently, bone has also been recognized as an endocrine organ, producing such hormones as osteocalcin, which modulates glucose tolerance and testosterone production (23,24).

Bones are formed by an outer layer of cortical bone covered by the periosteum. Bone marrow is found in the central parts of long bones, whereas trabecular bone is located in flat bones and in the metaphyseal area of long bones. The inner surface of cortical bone facing the bone marrow is covered by the endosteum. The cortical bone provides most of the strength of bones (25). Trabecular bone, on the other hand, can withstand high compressive loads (26).

Bone remodeling occurs constantly. This is facilitated by basic multicellular units (BMUs). The BMU comprises, in addition to other types of cells, osteoclasts responsible for bone resorption and osteoblasts responsible for bone formation (25). This balance of constant bone formation and resorption becomes negative in both sexes around midlife. However, the phenomenon is more pronounced in postmenopausal women (27).

4.2 How is a fracture sustained?

4.2.1 Mechanism of trauma

Fracture of a bone is caused by external trauma or in the case of pathological fracture by minimal or no trauma (27). Based on the mechanism of trauma, fractures are divided into low- and high-energy fractures. A low-energy fracture is usually defined as being sustained by energy equal to or less than a fall from standing height. In addition to this classical division, a third class of trauma, i.e. sports-related injuries, has been proposed (28). The comminution of fractures typically increases with increasing energy of trauma (29). The most severe injuries are frequently associated with a high-energy trauma mechanism (30).

Stress on normal bone may cause microfractures. If stress is repetitive and exceeds the capability of bone to repair these microfractures, a stress fracture occurs. Of stress fractures, 95% occur in the lower extremity of non-athletes or athletes increasing their training load (31).

4.2.2 Classification of fractures

In a clinical setting, fractures are typically classified according to the International Classification of Diseases, the tenth revision of which was published in 1990 (ICD-10). In this classification, diseases are grossly categorized using a diagnosis code including a letter followed by two specifying numbers. For example, in the code S72.0, S designates an injury, 72 the fracture of the femur, and 0 the fracture site on the head and neck of the femur. The external causes (mechanism of injury as well as the cause of the accident) are further specified with additional codes starting with the letters V through X (International Statistical Classification of Diseases and Related Health Problems, 10^{th} revision (ICD-10): WHO.fi).

In addition to the ICD-10 classification, fractures may be classified by the AO/OTA classification based on the morphology of the fracture (32). Further, numerous special classifications for specific fracture sites exist. For example, fractures of the lateral malleolus are commonly classified by Weber's classification (33), and femoral neck fractures may be classified by Garden's classification (34).

4.2.3 Risk factors for fractures

Risk factors for fracture can be divided into those that increase the risk for trauma, e.g. a fall, and those that have a negative effect on BMD. Further, poor socioeconomic condition may increase the risk for fracture (3).

Impaired mobility and balance, poor vision, cognitive impairment, history of falls, and neuromuscular, neurological, and heart disorders are identified as risk factors for falls (35). Risk factors for lowered BMD are low body mass index, history of fragility fracture, parental history of hip fracture, glucocorticoid treatment, and current smoking. Chronic conditions such as rheumatoid arthritis, inflammatory bowel disease, malabsorption, and immobilization may also decrease BMD (36).

Advanced age is associated with both increased risk for a fall as well as decreased BMD (36). Excessive alcohol consumption and especially binge drinking also increase the risk of injuries and decrease BMD (37,38). In addition, smoking and alcohol consumption are risk factors for injury-related deaths, at least in younger patients (39).

BMD usually peaks in the second and third decades of life depending on the site of measurement. For example, peak BMD is achieved earlier in the hip than in the lower spine (40). Age-related deterioration of bone structure may occur in cortical bone alone or in conjunction with deterioration of trabecular bone. Deterioration of cortical bone is concentrated at the endosteum. Expansion of bone occurs simultaneously at the periosteum, leading to an increase in bone diameter, despite the net weakening of the bone. The deterioration of bone is more pronounced in women than in men (36).

4.2.4 Osteoporosis

Osteoporosis has been defined as a "progressive systemic skeletal disease characterized by low bone mass and micro architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture" (41). Osteoporosis is associated with thinning of bone cortices and impaired trabecular bone structure, without affecting the trabecular bone thickness (41). Dual energy x-ray absorptiometry (DXA) has been defined as a means of measuring BMD for diagnosis of osteoporosis. Measurements are taken at the lumbar spine and hip. Results are expressed by T-scores. A T-score of 0 represents the normal BMD of a healthy young adult. A T-score of -2.5 or lower is diagnostic for osteoporosis (42). Although osteoporosis is diagnosed based on a low T-score, the disease presents itself clinically through low-energy fractures. Frequent sites for osteoporotic fractures are the hip, spine, and wrist (35). However, most fractures due to minor or moderate trauma in patients over 65 years of age are sustained by individuals without osteoporosis (42,43). Furthermore, even weak bones usually require some sort of stress that exceeds the loading capacity of the bone for a fracture to occur (44). Therefore, some experts think that for preventing osteoporotic fractures the focus should be on preventing falls instead of treating osteoporosis with medication (45).

4.3 Healing of fracture

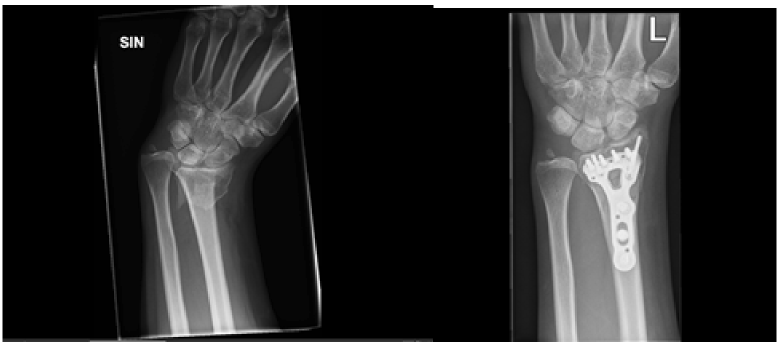
Soft tissues surrounding the fracture have an important role during fracture healing. One of these roles is to provide vascularization to the fracture zone. One-third of the blood supply of bone is provided by the periosteum covering the bone and two-thirds by the intramedullary vascular network (46). In addition, the periosteum provides the cells and growth factors needed for bone healing (47). Muscles cover the bones and give protection to the blood vessels vascularizing the periosteum and bone marrow. In some cases, muscle tissue can also have an influence on fracture healing by providing osteoprogenitor cells that secrete proteins that either enhance or inhibit osteogenesis (48). Further, the location of the fracture with respect to tendon attachments plays a role in fracture stability due to dislocating forces directed to the different fracture fragments through the tendons (49). Open fractures increase the risk for infection and non-union (50).

When a fracture is corrected operatively and anatomical reduction and rigid fixation of the fragments are achieved, the fracture heals by primary healing. Primary healing of bone occurs without the formation of a callus. Osteons travel across the fracture site, bridging the fracture gap (27,51).

Stabilization of the fractured bone with cast immobilization, external fixation, or intramedullary nailing allows micromovement at the fracture site. This will lead to secondary fracture healing. This type of healing is mediated by endochondrial healing (52). The hematoma formed at the fracture site induces an inflammatory process. An intricate, not fully understood cascade of signaling mediators is initiated. During the proliferative phase of secondary fracture healing the primitive soft callus at the fracture site turns into a cartilaginous callus. In the third phase, the soft callus is further modified into a bony callus. At the fourth phase of secondary fracture healing, the immature woven bone of the callus is converted into lamellar bone by a remodeling process. In this consolidation phase, the callus is reduced and the fractured bone is transferred towards its original shape. Fracture healing may take weeks to several months, and consolidation may take years (26,51-54).

4.4 Fracture treatment

For fractures to heal, sufficient stability of the fracture site and alignment of fracture fragments must be achieved (51). In most cases, this is possible non-operatively by cast immobilization and reduced weight bearing when the lower limb is affected. Generally, requirements for this type of conservative fracture treatment are moderate fracture dislocation and stable nature of the fracture. However, if the risk of complications due to such comorbidities as substance or alcohol use is increased, these criteria may be compromised. The same is true if the mobility of the patient has been severely impaired preceding the injury (55).



Dislocated distal radius fracture. Open reduction and internal fixation with volar plate.

As shown in Table 2, operative fracture treatment may be indicated if bone fragments are significantly dislocated or if immobilization of the fragments cannot be achieved by immobilization alone. Also, if a concomitant vascular injury is present, the fracture is treated operatively (56). Further, restoration of the articular surface and inherent instability of the fracture are indications for operative treatment (7). After operative reduction, which restores the shape of the bone, the bone fragments are immobilized with screws, plates, or metallic wires. Severe open fractures with associated extensive soft tissue injury can be fixed with external fixation. In the upper extremity, internal fixation is mainly achieved by using plates and wires (8,57,58). Plates, screws, and intramedullary nails are used for internal fixation of fractures of the lower extremity (57). When fractures are treated operatively, reduction is usually achieved by an open approach (open reduction internal fixation, ORIF) or by closed reduction and fixation of the fracture using percutaneous wires (59).

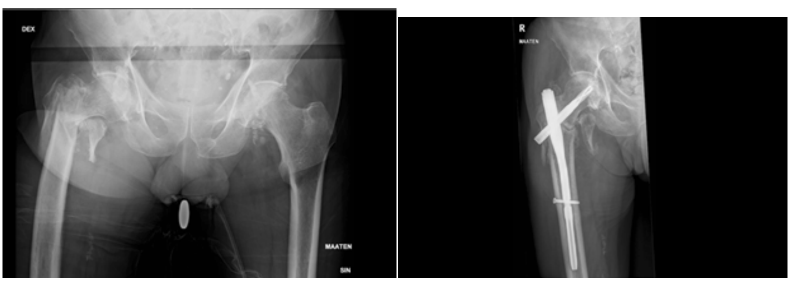
Table 1. Indications for operative fracture treatment.

Indications for operative fracture treatment
Adequate closed reduction is impossible
Faster mobilization and return to work (e.g. tibia shaft)
Inherent instability of fracture
Non-union
Restoration of articular surface
Severe soft tissue injury

Some dislocated fractures are associated with non-union due to poor blood supply of bone fragments. Dislocated femoral neck and humeral head fractures have a high tendency of non-union even after internal fixation, particularly in elderly patients. Therefore, these fractures may be treated often by primary joint replacement surgery (60).

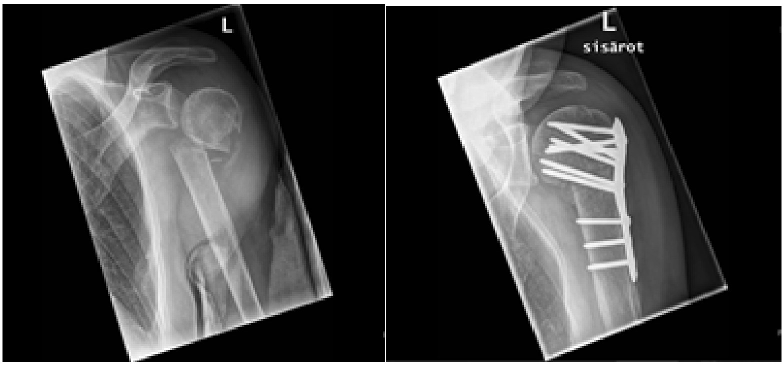
Further, some fractures benefit from operation, achieving better and faster functional results. This is true for fractures of the tibia diaphysis (11,61). Whether patients with displaced clavicle fractures are able to return earlier to work after operative treatment is controversial (62).

As stated earlier, some fractures, e.g. those of the hip and tibia shaft, are treated primarily by operation because of the major benefits in outcome over non-operative treatment. However, the rate of operative treatment of other types of fractures varies. Sumrein et al. (63) reported an operation rate in Sweden of 16.8% for women and 17.1% for men. The proportion of operations for clavicle fractures was 12.1% and for distal radius fractures 20% (62,64).



Pertrochanteric hip fracture. Osteosynthesis with intramedullary nail.

The management of non-operatively treated fractures can usually be done at outpatient clinics. Also, many upper extremity fractures and certain types of fractures of the distal lower limb can be surgically treated at a day-surgery unit, without the need for inpatient care. However, although outpatient treatment of a certain type of fracture (operative or non-operative) would be possible, concomitant injuries, general condition, and comorbidities of the patient frequently require inpatient care. Nevertheless, most fracture patients do not need hospitalization (5).



Proximal humerus fracture and osteosynthesis by using a plate and locking screws.

4.5 Incidence of fractures

The overall incidence of fractures ranges from 100 to 130/10 000 per year (1-3). In the general population, wrist, metacarpals, hip, finger phalanx, and ankle are the most common fracture sites, although the order of these fractures varies between studies (1-3).

Fractures of the hip, ankle, spine, wrist, and proximal humerus are the most common fractures treated in hospitals (1-3). The incidence of these fractures in Finland and Sweden is shown in Table 2 (65-69).

Table 2. Incidence of fractures most commonly treated in hospitals.

Author	Fracture	Fracture incidence per 100 000		Age group	Country
		Women	Men		
Kannus et al 2018	Hip	344	195	>50 years	Finland
Kannus et al 2016	Ankle	158	80	>60 years	Finland
Jansson et al 2010	Lumbar and thoracic spine	80.5 (both)		>60 years	Sweden
Brogren et al 2007	Wrist	390	120	>18 years	Sweden
Launonen et al 2015	Proximal humerus	114	47	>18 years	Finland

Most hip fracture patients are hospitalized. However, the majority of the remaining aforementioned fractures are treated at outpatient clinics or day-surgery units (5). Therefore, the incidence of hospitalized fractures differs from the overall fracture incidence in a population. The research on the incidence of fractures requiring hospitalization is limited, and to our knowledge only one previous study has included all types of hospitalized fractures (70).

4.6 Post-fracture mortality

Mortality following hip fracture is well documented and is of a magnitude 2-3 times that of the general population (12,13). The mortality is highest during the first year after the fracture (14). Also, osteoporotic vertebral fractures are associated with increased post-fracture mortality (1,14,15). The mortality after fractures other than hip and vertebrae require further investigation (16-20).

Post-fracture mortality research has traditionally focused on older adults, particularly those with hip fractures (17,20,71,72). However, some previous studies have suggested that the relative mortality after fractures increases with decreasing age (16,21).

Acute causes of death after major trauma are injury of the central nervous system, hemorrhagic shock with or without associated multiple organ failure, and acute respiratory distress syndrome (64).

However, with improving trauma care protocols combined with the advancing age of trauma patients, pre-existing medical conditions are starting to have an increasing impact on the survival of these patients (73). In patients older than 65 years, cardiovascular disease is the leading cause of post-fracture death (17,74). However, the causes of death of younger fracture patients have not previously been investigated.

5. Aims of the study

The aim of this thesis was to prospectively gather data about patients with fractures treated as inpatients. Specific aims were as follows:

1. To determine the incidence of all types of fractures in need of inpatient care. Special attention was given to non-hip fractures.
2. To examine the mortality and causes of death after different types of upper extremity fractures in adults of all ages.
3. To examine the mortality and causes of death after lower extremity fractures, with a special focus on non-hip fractures.
4. To investigate the post-fracture mortality in patients 16-30 years of age and to shed light on the causes of these deaths.

6. Materials and methods

All patients who were at least 16 years old and admitted to the trauma ward of Central Finland Hospital (CFH) in Jyväskylä, Finland, between January 2002 and December 2008 were prospectively included in a local register at CFH. Patients under the age of 16 years were treated at the Department of Pediatric Surgery and were excluded. CFH is the only public hospital in Central Finland Hospital District (CFHD). It offers trauma care to a population of 250 000, which comprises approximately 5% of the population of Finland. Fracture patients living in the catchment area of the hospital district in need of surgical treatment are referred to CFH. Fracture patients were hospitalized due to a planned surgical procedure, due to a severe fracture, or due to other patient characteristics (e.g. poor general condition, frailty associated with advanced age, or significant comorbidities).

Each trauma ward patient's social security number, municipality, diagnosis (ICD-10 code), procedure code (NOMESCO, Finnish version), code of external cause (ICD-10), side of injury, and time of arrival at the emergency department and ward were recorded in a registry. Complications during treatment were also recorded.

ICD-10-based fracture classification used for calculations is presented in Table 1. Some patients had records of repeated visits to the ward because of a similar fracture. For the sake of incidence calculation, all visits occurring within 2 months of the primary visit were regarded as being associated with additional treatment of the primary fracture. Repeat visits occurring later after the primary fracture were frequently recognized as being associated with the primary fracture by reviewing the records for secondary diagnoses, procedure codes, and complications. For the remaining cases, new fractures were distinguished from further treatment of a primary fracture by scrutinizing medical records, radiologist reports, and radiographs.

For mortality calculations, the first sustained fracture was regarded as the index fracture. Some patients presented with multiple fractures and simultaneous soft tissue injuries. The mortality rate for patients presenting with multiple fractures was calculated. However, the concomitant soft tissue injuries were not taken into account when calculating mortality rates for the different types of fractures.

The mortality status of patients by the end of 2012 and the causes of death were acquired from the Statistics Finland database. The causes of death were classified according to the ICD-10 classification.

Because this thesis is register-based, legislation does not require approval from an ethics committee. However, all register-based studies that utilize confidential medical information, such as patient charts and radiographs, require the approval of the corresponding institution or hospital. The review board of Central Finland Hospital approved the study protocol.

7. Statistics

Annual mean population sizes were used to assess the number of person-years in incidence calculations. The age of patients is presented as mean (SD) if not otherwise stated. Fracture incidence rates (per 1000 person-years) with 95% confidence intervals (CIs) were calculated assuming a Poisson distribution. Crude and standardized (age and sex) estimates of fracture incidence rate ratios (IRRs) were calculated using Poisson regression models, or negative binomial regression models when appropriate. Assumption of overdispersion in the Poisson model was tested using the Lagrange multiplier test.

The age- and sex-adjusted risk of mortality for each group investigated was estimated by using the Cox Proportional Hazards Model. The Standardized Mortality Ratio (SMR), defined as the ratio between the observed and expected numbers of deaths, was calculated based on the subject-years method, with 95% CIs, and assuming a Poisson distribution. The expected number of deaths was calculated on the basis of sex-, age-, and calendar period-specific mortality rates in the Finnish population.

8. Results

8.1 Incidence of fractures requiring inpatient care (Study I)

Between 2002 and 2008, altogether 3277 women sustained 3758 fractures and 2708 men sustained 3030 fractures. The incidence of all fractures requiring inpatient care was 4.9 per 1000 person-years (95% CI: 4.8 to 5.0); 5.3 (95% CI: 5.1 to 5.4) for women and 4.5 (95% CI: 4.3 to 4.6) for men. In patients younger than 55 years, the incidence of all fractures was higher in men. However, beyond this age the incidence of fractures increased rapidly in women and the fracture incidence was higher than that of men in the older age groups. This phenomenon is reflected in incidence rate ratios (IRRs) higher than 1 in Figure 1 after this age.

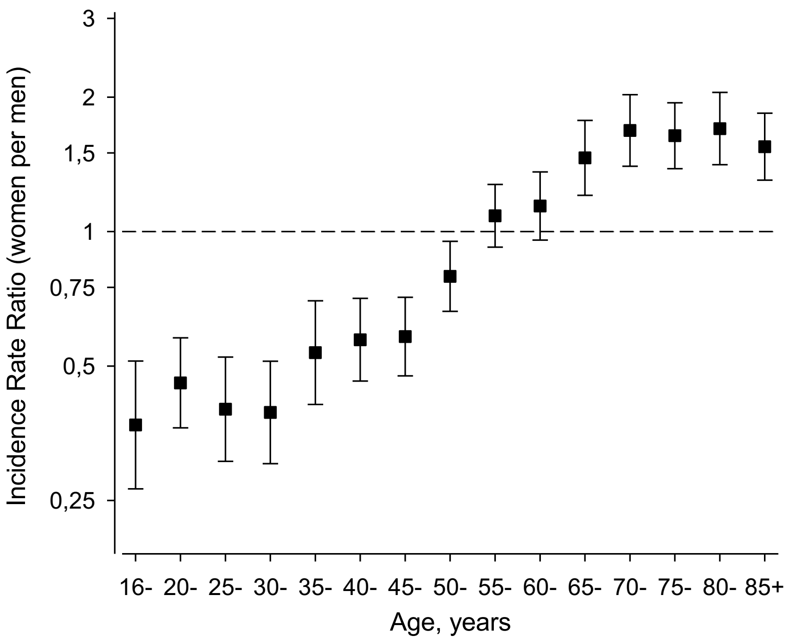


Figure 1. Incidence rate ratio by age of patients with fractures requiring inpatient care.

Female fracture patients were generally older than male patients (mean age 67 (SD 19) vs. 51 (SD 20) years; $p < 0.001$). In fact, 69% of female fracture patients (vs. 35% of men) were over 60 years of age. Overall, the age distribution of men was quite even until the age of 60 years, whereafter the numbers of male fracture patients decreased steadily. As an indication of the high fracture rate in elderly women, the number of fracture patients peaked at age 80 years, although the age distribution groups in women had already started to shrink at age 70 years (Figure 2).

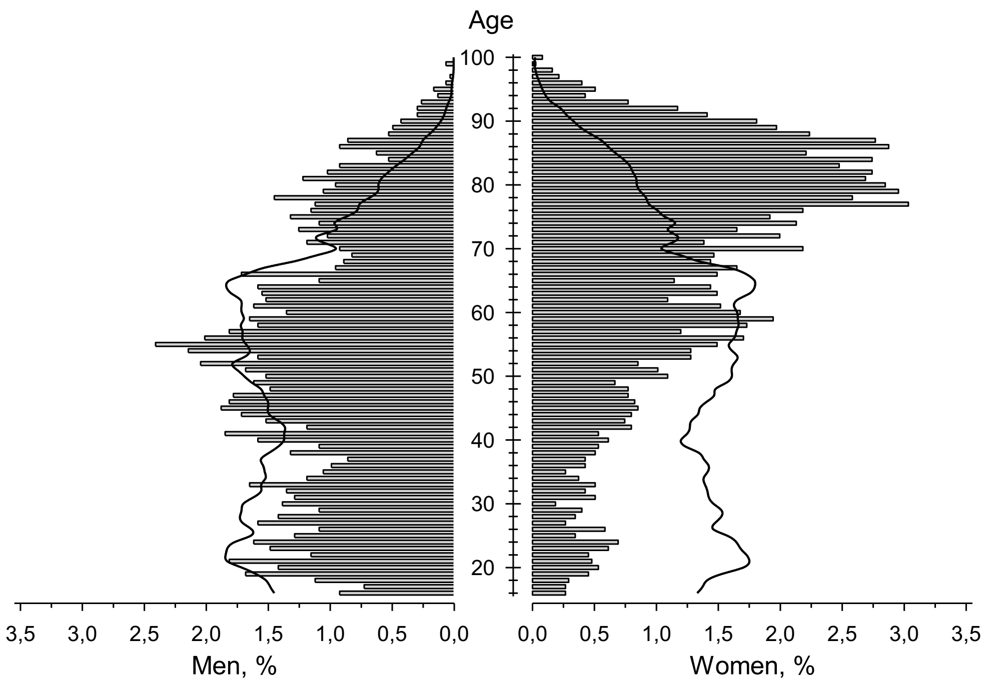


Figure 2. Age distribution of 3277 female and 2708 male fracture cohort patients (columns). The vertical lines indicate age distribution of the general population in Finland.

Table 3. Distribution of fractures requiring inpatient care between women and men**.**

Fracture	Diagnosis code	Women (N=3758)			Men (N=3030)	
		N (%)	Age (SD)		N (%)	Age (SD)
Hip	S72.0, S72.1, S72.2	1262 (33.6)	81 (10)		567 (18.7)	74 (14)
Ankle	S82.5, S82.6, S82.8	597 (15.9)	55 (16)		557 (18.4)	46 (16)
Radius/ulna, distal	S52.5, S52.6, S52.8	429 (11.4)	65 (15)		188 (6.2)	47 (17)
Spine	S12, S22.0, S22.1, S32.0	130 (3.5)	55 (21)		251 (8.3)	47 (19)
Humerus, proximal	S42.2	239 (6.4)	69 (14)		119 (3.9)	55 (17)
Forearm, proximal	S52.0, S52.1	129 (3.4)	59 (21)		71 (2.3)	48 (17)
Tibia, distal	S82.3	96 (2.6)	55 (18)		108 (3.6)	46 (16)
Tibia, diaphysis	S82.2	75 (2.0)	49 (17)		111 (3.7)	42 (17)
Clavicle	S42.0	53 (1.4)	47 (21)		124 (4.1)	42 (16)
Femur, diaphysis	S72.3	119 (3.2)	74 (20)		71 (2.3)	46 (24)
Tibia, proximal	S82.1	97 (2.6)	61 (17)		76 (2.5)	46 (16)
Finger phalanx	S62.5, S62.6, S62.7	27 (0.7)	49 (17)		108 (3.6)	43 (15)
Patella	S82.0	52 (1.4)	65 (16)		63 (2.1)	50 (19)
Humerus, distal	S42.3	80 (2.1)	64 (20)		39 (1.3)	54 (22)
Femur, distal	S74.2	86 (2.3)	76 (15)		35 (1.2)	52 (20)
Shaft of forearm	S52.2, S52.3, S52.4	51 (1.4)	57 (20)		58 (1.9)	41 (17)
Metacarpal	S62.2, S62.3, S62.4	31 (0.8)	46 (21)		75 (2.5)	39 (16)
Diaphysis, humerus	S42.3	54 (1.4)	66 (19)		40 (1.3)	50 (21)
Fibula*	S82.4	20 (0.5)	53 (14)		75 (2.5)	42 (14)
Calcaneus	S92.0	16 (0.4)	48 (17)		66 (2.2)	44 (13)
Metatarsal	S92.3	27 (0.7)	51 (18)		53 (1.7)	42 (16)
Acetabulum	S32.4	19 (0.5)	66 (27)		47 (1.6)	57 (20)
Pelvis	S32.1, S32.3, S32.5	38 (1.0)	67 (24)		25 (0.8)	50 (21)
Scapula	S42.1	15 (0.4)	58 (20)		34 (1.1)	52 (15)
Toe phalanx	S92.4, S92.5	4 (0.1)	41 (26)		23 (0.8)	45 (13)
Carpus	S62.0, S62.1	6 (0.2)	55 (16)		19 (0.6)	46 (16)
Talus	S92.1	4 (0.1)	26 (5)		17 (0.6)	37 (13)
Midfoot**	S92.2	2 (0.1)	42 (19)		10 (0.3)	38 (12)

*malleolus excluded

**Cuboid, navicular, cuneiform

Table 4. Incidence and incidence rate ratio (IRR) (female to male) of fractures requiring inpatient care.

Fracture	Annual Rate / 1000 (95% CI)		IRR (95% CI)†	P-value†
	Women	Men		
Hip	1.77 (1.67 to 1.87)	0.83 (0.77 to 0.90)	1.20 (1.08 to 1.33)	<0.001
Ankle	0.84 (0.77 to 0.91)	0.82 (0.75 to 0.89)	1.03 (0.92 to 1.15)	0,64
Radius/ulna, distal	0.60 (0.54 to 0.66)	0.28 (0.24 to 0.32)	1.95 (1.64 to 2.32)	<0.001
Spine	0.18 (0.15 to 0.22)	0.37 (0.32 to 0.42)	0.47 (0.38 to 0.59)	<0.001
Humerus, proximal	0.33 (0.29 to 0.38)	0.17 (0.14 to 0.21)	1.62 (1.29 to 2.02)	<0.001
Tibia, distal	0.13 (0.11 to 0.16)	0.16 (0.13 to 0.19)	0.84 (0.64 to 1.11)	0,22
Forearm, proximal	0.18 (0.15 to 0.21)	0.10 (0.08 to 0.13)	1.59 (1.19 to 2.13)	0,002
Femur, diaphysis	0.17 (0.14 to 0.20)	0.10 (0.08 to 0.13)	1.14 (0.84 to 1.54)	0,39
Tibia, diaphysis	0.10 (0.08 to 0.13)	0.16 (0.13 to 0.20)	0.66 (0.49 to 0.89)	0,006
Clavicle	0.07 (0.06 to 0.10)	0.18 (0.15 to 0.22)	0.41 (0.30 to 0.57)	<0.001
Tibia, proximal	0.14 (0.11 to 0.17)	0.11 (0.09 to 0.14)	1.15 (0.85 to 1.56)	0,36
Finger phalanx	0.04 (0.02 to 0.05)	0.16 (0.13 to 0.19)	0.25 (0.17 to 0.38)	<0.001
Femur, distal	0.12 (0.10 to 0.15)	0.05 (0.04 to 0.07)	1.65 (1.11 to 2.47)	0,014
Humerus, distal	0.11 (0.09 to 0.14)	0.06 (0.04 to 0.08)	1.61 (1.09 to 2.38)	0,016
Patella	0.07 (0.05 to 0.10)	0.09 (0.07 to 0.12)	0.71 (0.49 to 1.03)	0,068
Shaft of forearm	0.07 (0.05 to 0.09)	0.09 (0.06 to 0.11)	0.81 (0.55 to 1.18)	0,28
Metacarpal	0.04 (0.03 to 0.06)	0.11 (0.09 to 0.14)	0.41 (0.27 to 0.63)	<0.001
Fibula*	0.03 (0.02 to 0.04)	0.11 (0.09 to 0.14)	0.27 (0.17 to 0.45)	<0.001
Humerus, diaphysis	0.08 (0.06 to 0.10)	0.06 (0.04 to 0.08)	1.08 (0.72 to 1.64)	0,71
Calcaneus	0.02 (0.01 to 0.04)	0.10 (0.07 to 0.12)	0.24 (0.14 to 0.42)	<0.001
Metatarsal	0.04 (0.02 to 0.05)	0.08 (0.06 to 0.10)	0.50 (0.32 to 0.80)	0,004
Acetabulum	0.03 (0.02 to 0.04)	0.07 (0.05 to 0.09)	0.29 (0.17 to 0.51)	<0.001
Pelvis	0.05 (0.04 to 0.07)	0.04 (0.02 to 0.05)	1.13 (0.68 to 1.90)	0,64
Scapula	0.02 (0.01 to 0.03)	0.05 (0.03 to 0.07)	0.41 (0.22 to 0.75)	0,004
Toe phalanx	0.01 (0.00 to 0.01)	0.03 (0.02 to 0.05)	0.17 (0.04 to 0.72)	0,016
Carpus	0.01 (0.00 to 0.02)	0.03 (0.02 to 0.04)	0.31 (0.11 to 0.97)	0,045
Talus	0.01 (0.00 to 0.01)	0.02 (0.01 to 0.04)	0.24 (0.05 to 1.29)	0,097
Midfoot **	<0.01 (0.00 to 0.01)	0.01 (0.01 to 0.03)	0.21 (0.02 to 1.76)	0,15

*malleolus excluded

**Cuboid, navicular, cuneiform

†Age adjusted

Fractures of the hip, ankle, wrist, spine, and proximal humerus were the most common ones, comprising 64% of all fractures requiring hospitalization (Table 3). Hip fracture patients were significantly ($p<0.001$) older than the rest of these patients. The incidences of fractures at all different fracture sites are presented in Figure 3. IRRs (female to male) are presented in Table 4.

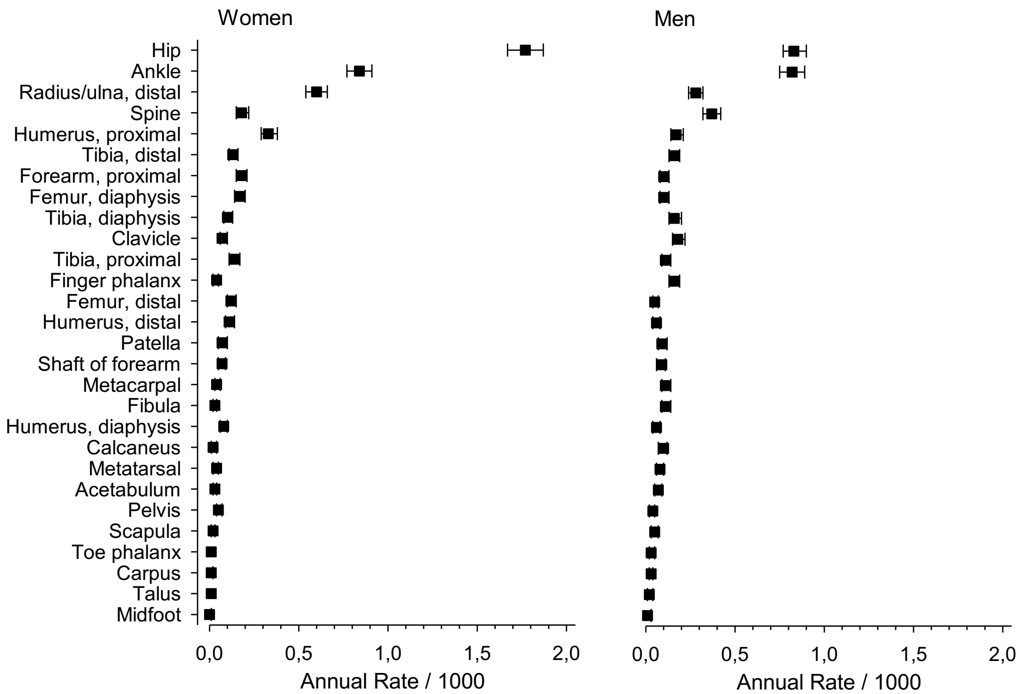


Figure 3. Incidence of fractures requiring inpatient care. Error bars indicate 95% confidence intervals.

8.2 Mortality after upper and lower extremity fractures requiring hospitalization (Studies II and III)

Between 2002 and 2008, a total of 929 women and 753 men sustained at least one upper extremity fracture and 2081 women and 1486 men at least one lower extremity fracture. The mean duration of follow-up for upper extremity fractures was 6.0 years and for lower extremity fractures 5.0 years. At the end of the follow-up period, 179 women and 105 men with upper extremity fractures and 877 women and 476 men with lower extremity fractures had died. The combined cumulative mortality of these fracture patients is presented in Figure 4.

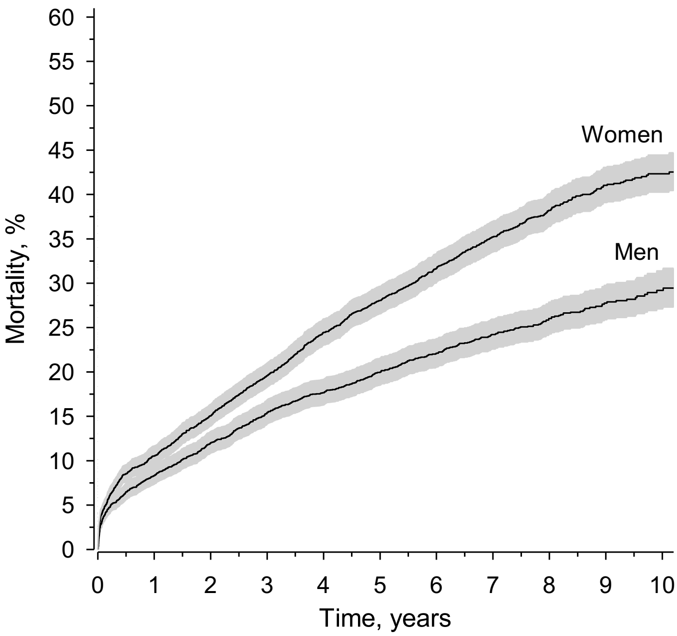


Figure 4. Combined cumulative mortality of upper and lower extremity fracture patients.

Both women and men with lower extremity fractures were generally older than their counterparts with upper extremity fractures [women 70.2 (SD 18.2) vs. 62 (SD 18) years and men 55.3 (SD 21.0) vs. 46 (SD 17) years]. The ages of deceased fracture patients in relation to ages of deceased patients in the general Finnish population are presented in Figure 5.

Figure 5. Age distribution of deceased fracture cohort patients (columns) and the general population (vertical lines).

The SMR of all fracture patients was 1.83 (95% CI: 1.75 to 1.91); 1.65 (95% CI: 1.56 to 1.75) for women and 2.56 (95% CI: 2.09 to 2.43) for men. The highest SMRs were seen in the youngest patients with fractures (Figure 6).

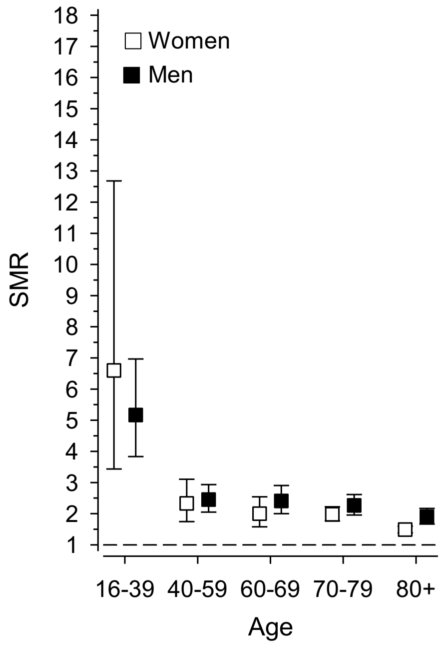


Figure 6. Combined standardized mortality rate ratio of upper and lower extremity fracture patients by age.

The SMR was higher after lower extremity fractures than upper extremity fractures [1.89 (95% CI: 1.76 to 2.02) vs. 1.32 (95% CI: 1.14 to 1.53) for women and 2.61 (95% CI: 2.38 to 2.85) vs. 2.06 (95% CI: 1.70 to 2.50) for men]. Proximal fractures of both the upper and lower extremity were associated with higher SMRs than distal fractures. However, in men the SMR after proximal humerus fracture was even higher than after hip fracture [4.50 (95% CI: 3.31 to 6.11) vs. 3.0 (95% CI: 2.7 to 3.3)].

8.3 Post-fracture mortality in patients aged 16-30 years (Study IV)

Between 2002 and 2008, altogether 724 patients (72.5% men), aged 16 to 30 years, were hospitalized for treatment of a fracture in CFH. Ankle, tibia, spine, forearm, and wrist constituted the five most common fracture sites. The median follow-up time was 7.4 years.

By the end of the follow-up period in 2012, among these 724 young patients with fractures, 6 women and 23 men had died. The SMR of all patients was 6.17 (95% CI: 4.29 to 8.88). The SMRs for women and men were 11.16 (95% CI: 5.02 to 24.85) and 5.52 (95% CI: 3.67 to 8.31), respectively. No patient's death during the treatment period was associated with the index fracture.

Suicide (28%) and intoxication (24%) were the leading primary causes of death. Motor vehicle accidents (MVA) and homicides accounted for 17% and 10% of deaths, respectively. In 33% of deaths in women and 48% of deaths in men, a mental or behavioral disorder (ICD-10 subgroup F) was listed as a contributing cause of death.

9. Discussion

9.1 Methodological considerations

9.1.1 Study strengths

In Finland, all deaths and causes of death are recorded by Statistics Finland. Therefore, accurate data exist on the mortality of fracture patients as well as of the general population (75). This makes it possible to calculate SMRs, which are the relationships between mortality in a cohort and the general population. Thus, SMRs enable accurate comparison of mortality in different populations (76).

Finnish public healthcare is publicly funded and provided to every citizen at minimal cost. People may also use a private healthcare provider. In this case, treatment is paid by insurance companies, employers, or the patients themselves.

At the time of the study, no private hospital offering inpatient care existed in the catchment area of CFH. Most fracture patients in need of specialized trauma treatment in the CFHD were referred to CFH. Therefore, most patients with serious fractures requiring inpatient treatment who lived in the catchment area of CFH were probably included in the current register. The possibility of some missing diagnoses or inaccurate entries in the registry cannot be excluded. Also, some patients may have been injured while traveling domestically or abroad and been treated acutely at a local hospital, with follow-up arranged via CFHD as an inpatient or outpatient at CFH. However, a study on hip fractures between 2002 and 2003 at CFH, based on different records, found a similar incidence of hip fractures to that presented here (77). Thus, our data are most likely reliable.

The research material did not differentiate between continued treatment of a previous fracture and a new fracture when a patient was repeatedly admitted to the ward with a similar fracture diagnosis. For the sake of incidence calculations, multiple ward visits for a similar fracture within 2 months of the first visit were regarded as being part of the treatment of the primary fracture. The cut-off period of 2 months was short. Therefore, every case of re-admission for the same diagnosis more than 2 months after the primary fracture was manually evaluated. Thus, re-fractures were probably reliably identified.

9.1.2 Study limitations

Fractures of the cervical spine that required surgery may have been referred elsewhere, without being transferred to the ward. Similarly, some patients with a fracture and an associated severe traumatic brain injury that required neurosurgical treatment were referred directly to another hospital district by the paramedics. Also, some patients that presented at the emergency department with a fracture that was treated non-operatively might have been directly transferred, e.g. due to poor general condition, to another hospital for inpatient care. These factors may lead to an underestimation of fracture incidences.

Vertebral fractures are heterogenic. At one end of the spectrum are osteoporotic compression fractures of elderly individuals and in the other end fractures that have been sustained by high-energy trauma mechanism (78,79). The register did include an ICD-10 code for mechanism of trauma. However, we regarded these entries as being too unreliable for inclusion in the analyses. Differentiation between the different categories of vertebral fractures was therefore not possible based on the current register. Thus, we were unable to present meaningful mortality data on these fractures.

With an incidence of approximately 100/10 000 person-years, fractures are common (1-3). Thus, several patients in the general population are bound to have sustained a fracture. Our results may underestimate the increased mortality associated with fractures.

The Finnish National Hospital Discharge register did not include outpatients at the time of the study. Therefore, we were unable to compare our findings with outpatients sustaining similar fractures. For example, reporting the proportion of all patients (outpatients and inpatients) who had undergone an operation or the proportion of patients needing hospitalization was impossible. We were also unable to compare inpatient and outpatient mortality rates.

For mortality calculations, the first sustained fracture of interest (upper or lower extremity) was considered the index fracture. However, some patients may have previously or subsequently sustained another fracture that, in fact, may have added to the observed mortality. This may lead to overestimation of the mortality presented as being associated with a certain type of fracture.

Some fracture patients with benign injuries may have been transferred directly from the emergency department to the operating room and discharged directly from the recovery room, therefore not being included in the register. However, these patients are probably rare.

A small portion of pathologic fractures might have been registered as traumatic fractures. The underlying malignancy may have increased the observed mortality.

9.2 Incidence of fractures requiring inpatient care (Study I)

Based on a material of 6788 fracture treatment periods, we determined the incidence of all fractures requiring inpatient care. Few studies have previously investigated the incidence of all hospitalized fracture types in adults, and to our knowledge, only one earlier study has addressed all hospitalized fracture types in adults of all ages (70). In concordance with previous results, hip fractures constituted the largest group of fractures requiring inpatient care (27%). However, in our material ankle fractures represented a substantially larger proportion (17%) of all hospitalized fractures than previously reported (5%) (70). Further, the combined incidence of ankle and wrist fractures (9%) was similar to the incidence of hip fractures.

Many epidemiological studies have focused on the overall incidence of fractures (2,80-82). According to the literature, fractures of the distal radius, metacarpals, hip, finger phalanx, and ankle are the most common types (2). This fracture profile is remarkably different from that for hospitalized fracture patients. In our sample, we found that hip, ankle, spine, wrist, and proximal humerus fractures were the fractures most frequently requiring hospital admission. This is in agreement with the results from other studies (3,83).

Inpatient hospital treatment of fractures is much more expensive than outpatient fracture treatment (84). If surgery is needed, the costs are even higher (9). However, the majority of the total expenses associated with operative fracture management are indirect costs due to absence from work (85). Thus, prevention of fractures that commonly require surgical treatment is cost-effective. With the exception of ankle fractures, all of the top five fractures requiring hospitalization (hip, wrist, spine, and proximal humerus) might be related to lowered mechanical strength of the bone due to aging of the patients (86). A proportion of these fractures might be circumvented by effectively preventing falls and treating osteoporosis. However, as previously stated, most fractures in patients over 65 years of age are sustained by people without osteoporosis (42,43). Also, the effectiveness of pharmacological osteoporosis treatment in preventing fractures has been questioned (43). Therefore, a larger proportion of these fractures may be averted by preventing falls. Further, especially younger individuals frequently sustain fractures by high-energy trauma (28).

The most important reasons for admission to hospital are likely to be the type and severity of the fracture and the need for operative treatment. In our study, operative treatment was required in 82% of the fracture cases admitted to the trauma ward. Other causes for trauma ward admissions may include concomitant injuries requiring surgical inpatient care or analgesic treatment, advancing age, and severe comorbidity (87). At the population level, most fractures are treated non-operatively; in fact only one-third of all fractures in adults are surgically treated (88) Approximately half of the fracture patients presenting at the emergency department need hospitalization (5).

Ambulatory fracture surgery at a day-surgery unit seems cost-effective and reduces the need for hospitalization (89). In our material, wrist fractures constituted the third largest group of fracture inpatients. During the last few years a growing portion of simple isolated fractures (especially wrist fractures) in otherwise relatively healthy individuals presenting at CFH are operated on at the day-surgery unit. Due to the recent change to a more day-surgery-oriented fracture treatment strategy, the number of wrist fracture patients in the trauma ward has decreased markedly during the last years. At the moment, approximately 30% of all fracture operations at CFH are done at the day-surgery unit.

9.3 Mortality after extremity fractures requiring inpatient care (Studies II and III)

In a representative material, we observed that all extremity fractures were associated with an increased mortality. The mortality was higher in men than in women. The SMR was highest after proximal fractures of both lower and upper limbs and decreased with advancing age of patients. The general mortality was higher after lower extremity fractures than after upper extremity fractures. However, proximal humerus fractures in men formed an exception by being associated with a higher mortality than hip fractures.

Extensive comparison of results on post-fracture mortality is difficult due to differences in study populations, ways of expressing mortality, and categorization of fracture sites (14,17-19,21,72,90-92). Even for hip fractures, only a few studies have reported SMRs. For hip fractures, our SMRs of 2.0

(95% CI: 1.8 to 2.1) for women and 3.0 (95% CI: 2.7 to 3.3) for men are similar to results from Australia (12,13). However, Melton et al. (20) reported a slightly lower SMR after hip fractures for women in the United States. Their study reported SMRs similar to ours after proximal humerus fractures caused by low- or moderate-energy trauma.

We found that fractures of the proximal extremity were associated with increased mortality in both younger and older patients. Elderly people usually sustain hip fractures from low-energy trauma and frequently have decreased bone mineral density (36,84). Traditionally, it has been argued that older people who sustain proximal fractures are frail and suffer from comorbidities (20,84). Conversely, it has been speculated that those who sustain fractures of the distal lower extremity may be healthier and more active than their peers who sustain more proximal fractures (16,18).

The mortality was also generally higher after lower extremity fractures than after upper extremity fractures. This might be due to impaired ambulation after lower extremity fractures. In fact, elderly hip fracture patients who walk early after surgery are more likely to survive (93). Heinonen et al. (94) found that reduced mobility two weeks post-operatively in patients who previously had been able to walk predicted increased one-year mortality.

In younger patients, hip fractures are more frequently sustained by high-energy or sports-related trauma (28). Al-Ani et al. (28d) found that the majority of these patients had at least one risk factor for fracture and lower mineral density. Otherwise, these patients were generally reasonably healthy.

9.4 Post-fracture mortality in patients aged 16-30 years (Study IV)

Studies II and III of this thesis demonstrated an increased post-fracture mortality in young adults. This was also supported by data from other studies reporting an increased relative mortality with decreasing age (16,21). However, the phenomenon had not to our knowledge been investigated in more detail. A novel finding was that the mortality of patients aged 16-30 years treated as inpatients for fracture was over 6-fold that of the general population when controlled for age, sex, and calendar period. Further, suicide and intoxication accounted for over half of the causes of death in these patients.

The causes of death among young patients with fractures differed understandably from those among older patients. In older age groups of the current register, cardiovascular disease accounted for nearly half the deaths. In contrast, among young adults, over half of the deaths following inpatient fracture treatments were due to suicide or intoxication. This finding is consistent with previous research on young individuals who had committed suicide; Viilo et al. (95) noted that 33% of young males and 44% of young females committing suicide had earlier been treated in-hospital for an injury or intoxication. Mattila et al. (96) observed that fractures are common among psychiatric outpatients. Also, young trauma victims are more often under the influence of alcohol or drugs than patients over 60 years of age (95). Overall, drunkenness seems to be associated with an increased risk of fractures (97).

We hypothesized that deaths could be divided into two groups based on the underlying psychopathology. The first group comprises suicides and deaths due to intoxication, which may be associated with depressive disorders. In psychological autopsy studies, up to 90% of individuals committing suicide were shown to have depression, either diagnosed or undiagnosed (98,99). Furthermore, substance use disorders are commonly associated with depression (100). The second group is formed by deaths due to motor vehicle accidents and homicides. These deaths might be indicative of underlying impulse control disorders (101,102). However, in this group of patients, depression and alcohol abuse are also commonly associated (103,104).

Our results suggest that some young adults receiving inpatient fracture care may suffer from a possibly undiagnosed, serious mental illness. Health professionals should take this into consideration when treating young adults hospitalized for a fracture. Additional factors may, however, also have an impact on post-fracture mortality in young patients. Poor socioeconomic background seems to correlate with adverse health behavior, injuries, and accidents (105,106).

10. Conclusions

1. Although hip fractures (27%) constituted the largest group of fractures requiring inpatient care, the combined incidence of ankle (17%) and wrist fractures (9%) was similar to the incidence of hip fractures. The incidence of ankle fractures was higher than previously reported.
2. Mortality was increased after all extremity fractures. Proximal fractures of both the upper and lower extremity were associated with a higher mortality than distal fractures. This might be due to a healthier and more active lifestyle of individuals who sustain fractures of the distal limbs. Also, upper extremity fractures were generally associated with lower mortality than lower extremity fractures. This might be due to the higher degree of impaired ambulation associated with lower extremity fractures.
3. In older fracture patients, the actual causes of increased post-fracture mortality are unclear. Part of the increased risk seems to be attributed to the fracture itself. However, we, among many others, speculate that comorbidities and frailty have an important role as contributing factors to the observed increase in mortality. This relation should be examined in more detail.
4. We observed a six-fold relative post-fracture mortality in 16–30-year-old fracture patients. Suicide and intoxication constituted the two most common causes of death. This led us to believe that a mental disorder may have been present in these patients. We believe that psychopathology is a strong risk factor for increased mortality in young fracture patients. However, other factors, such as socioeconomic status, might also play an important role. Therefore, further investigation of this issue is warranted.

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Helsinki, September 2018

Axel Somersalo

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